2

MTL TR 90-47

AD

MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING

AD-A228 013

ERNEST N. KINAS and CHARLES F. HICKEY, Jr.
MATERIALS PRODUCIBILITY BRANCH

September 1990

Approved for public release; distribution unlimited.

US ARMY
LABORATORY COMMAND
MATERIALS TECHNOLOGY LABORATORY

U.S. ARMY MATERIALS TECHNOLOGY LABORATORY
Watertown, Massachusetts 02172-0001

90

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MTL TR 90-47	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING		5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Ernest N. Kinas and Charles F. Hickey, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Materials Technology Laboratory Watertown, Massachusetts 02172-0001 SLCMT-MEM		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Laboratory Command 2800 Powder Mill Road Adelphi, Maryland 20783-1145		12. REPORT DATE September 1990 13. NUMBER OF PAGES 7
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Titanium alloys	Physical properties
Forgings	Heat treatment
Artillery shells	Mechanical properties
Microstructure	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(SEE REVERSE SIDE)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

Block No. 20

ABSTRACT

This paper addresses a mechanical property investigation on Ti-6Al-6V-2Sn which is used for the rear body component of the T5119 artillery torsional impact test projectile. Quantities of this projectile were produced during 1988 and 1989 at the U.S. Army Materials Technology Laboratory (MTL) upon request from PM-NUC. These projectiles had been produced at MTL approximately 10 years ago. In the earlier work, a die which resulted in a forged wall thickness less than 1 inch, which is customary for this component, was used. In the recent program, a substitute die which resulted in a heavier forged wall thickness of approximately 1-5/8 inch had to be used. This was necessary due to the fracture failure of the customary die. Because of the time constraints placed upon MTL by PM-NUC to produce and deliver both the T5119 and T5106 test projectiles, time was not available to make a replacement die; therefore, it was necessary to conduct a heat treatment study of the thicker wall forgings in order to meet the mechanical property requirements for the rear body component. One solution temperature and five aging temperatures were used in this investigation. Tensile and Charpy impact properties were obtained in addition to other factors such as sampling procedures and microstructure. As a result of these findings, an optimum heat treatment for the investigated conditions was established that met the design mechanical properties for this artillery shell component.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

BACKGROUND AND INTRODUCTION

The rear body material for the 155-mm T5119 torsional test projectile is specified to be Ti-6Al-6V-2Sn. This titanium alloy is also used for the same component in the 454 nuclear round. The major reason for the selection of titanium is weight reduction versus steel. The Ti-6Al-6V-2Sn alloy is specified because it can be heat treated to the required mechanical properties. The mechanical properties specified for this part, called **Body Section Rear,** are: (1) 170 ksi yield strength at 0.1% offset, (2) 6% elongation, (3) 13% reduction of area, and (4) Charpy V-notch impact toughness of 6 ft-lb at -40°F.

The T5119 test projectile is used to measure the torsional impact on the projectile within the gun tube at the point of engagement with the rifling. It contains triaxial accelerometers that measure axial accelerations (TWIST), that occur when the projectile engages the gun tube rifling. Projectile axial acceleration must be kept within limits since excessive axial acceleration will result in projectile component breakup or ballistic performance failure. Extensive research was conducted in this area by Bluhm et al. at the Watertown Arsenal in the early 1960s.[1]

Rear bodies for the T5119 were made at the Watertown site in the late 1970s using conventional forging practice that generated a forging wall thickness of less than 1" and a heat treatment was established to meet the specified mechanical properties.

Most recently, the U.S. Army Materials Technology Laboratory (MTL), formerly Watertown Arsenal, was requested by PM-NUC at the U.S. Armament Research, Development, and Engineering Center (ARDEC) to fabricate for delivery to West Germany 16 T5119 and 44 T5106 test projectiles. The T5106 projectile is used to measure the external ballistics such as range distance and time in flight, both of which must also be duplicated in the firing of the 454 nuclear projectile. This program was scheduled as an 18-month effort. However, funding was not received until six months later which meant that the program had to be completed in less than 12 months.

The purpose of this report is to present the results of a heat treatment study which had to be conducted on the titanium rear body forgings. This study was necessitated by the fact that the forging die which was used for the fabrication of the rear bodies in the late 1970s fractured at the start of the MTL forging operation. The time limitation did not allow for the making of a new die; therefore, a substitute die, which resulted in a substantially thicker wall section (1-5/8" thickness) had to be used. A new heat treatment had to be established in an attempt to meet the mechanical property specifications.

MATERIALS AND EXPERIMENTAL PROCEDURE

Ti-6Al-6V-2Sn is a heat treatable α plus β alloy that, in many aspects, is similar to Ti-6Al-4V but contains increased content of β stabilizing elements; especially vanadium, which provides higher strength potential at a sacrifice in toughness and weldability. This alloy can be heat treated to an ultimate tensile strength in excess of 170 ksi. The strength obtainable is related to forged section size. The response to heat treatment may vary from heat-to-heat and the correct aging temperature is best determined by tests on the heat in question.[2] The chemistry of this alloy (as obtained at MTL) is shown in Table 1.

1. BLUHM, J. I. et al. *T-5094 Aft Joint* Report of Redesign Conducted by the Staff of Watertown Arsenal Internal W/A RPT 1962
2. Aerospace Structural Metal Handbook, v. 4, 1975, Code 3715, p 1.

Table 1. CHEMICAL COMPOSITION OF Ti-6Al-6V-2Sn TESTED IN WEIGHT PERCENT

Al	V	Sn	Cu	Fe	C	N	O	H_2	Ti
5.98	5.31	2.0	0.84	0.84	0.03	0.017	0.189	0.008	Balance

MTL purchased 6-1/4"-diameter Ti-6Al-6V-2Sn barstock in the commercial grade mill annealed condition. This barstock was cut into billets which, in turn, were faced off to 7-1/4" lengths. A 3/4" radius was machined on both ends to eliminate sharp corners. Following billet preparation, these billets were coated with a proprietary glass coating which served the dual function of protecting the titanium alloy surface from oxidation, as well as a forging lubricant.

The billets were heated to 1650°F and forged on a 2000-ton hydraulic forging press. Following the forging operation, the billets were immediately water quenched which is a customary practice in titanium forging. These forgings were then rough machined in preparation for heat treatment. The components had substantial amounts of material removed to enhance the titanium alloy's responses to water quenching after solution treatment. The titanium alloy wall thickness should be no greater than 1" to maximize the transformation response during heat treatment.

In order to meet the minimum mechanical properties for the body section rear (170 ksi at 0.1% offset, 6% elongation, 13% reduction of area, and 6 ft-lb Charpy impact energy at -40°F), a heat treatment study was conducted to achieve the optimum combination of mechanical properties.

Although MTL was allowed to lower the minimum yield strength from 170 ksi at 0.1% offset to 160 ksi, extensive efforts in exploring various solution and aging treatments were made to meet the required minimum specifications. Table 2 shows the heat treatments performed in this study.

Table 2. HEAT TREATMENT FOR Ti-6Al-6V-2Sn REAR BODY SECTIONS

Specification Identification	Solution Treatment (°F)	Aging Treatment (°F)
3Q	1600, 2 Hours, W. Q.	950 4.5 Hours, A.C.
3H	1600, 2 Hours, W. Q.	975 4.5 Hours, A.C.
2QB	1600, 2 Hours, W. Q.	1025 4.5 Hours, A.C.
2QA	1600, 2 Hours, W. Q.	1050 4.5 Hours, A.C.
1A	1600, 2 Hours, W. Q.	1075 4.5 Hours, A.C.

RESULTS

The mechanical property results for the various heat treatments are tabulated in Table 3. Tensile specimens were taken in the transverse direction. Charpy impact specimens were also taken in the transverse direction with the crack propagating in the radial direction (T-R). Data is based on two individual tests and then averaged.

Table 3. MECHANICAL PROPERTIES OF Ti-6Al-6V-2Sn SOLUTION TREATED AT 1600°F, 2 HOURS, WATER QUENCHED, AGED FOR 4-1/2 HOURS, AIR COOLED

Specification Identification	Aging Temp. (°F)	0.1 % Y.S. (ksi)	0.2 % Y.S. (ksi)	U.T.S. (ksi)	Elon. (%)	R.A. (%)	Charpy Impact -40°F (ft-lb)
3Q	950	164	169	190	8.8	17.6	8.5
		168	171	189	5.9	16.8	8.2
		166*	170*	190*	7.4*	17.2*	8.4*
3H	975	171	174	183	9.1	18.9	8.7
		164	168	186	9.1	20.4	8.7
		168*	171*	185*	9.1*	19.7*	8.7*
2QB	1025	161	165	181	13.2	30.3	9.0
		163	167	186	13.0	15.3	9.0
		162*	166*	184*	13.1*	22.8*	9.0*
2QA	1050	157	159	169	11.6	30.2	9.5
		157	159	175	11.5	26.0	10.0
		157*	159*	172*	11.6*	28.1*	9.8*
1A	1075	159	163	175	7.3	13.8	10.1
		161	164	175	9.3	15.3	10.3
		160*	164*	175*	8.3*	14.6*	10.2*

*Average.

The heat treatment selected was (3H) 1600°F, 2 hours, W.Q., and age at 975°F, for 4-1/2 hours, A.C. This heat treatment resulted in the highest yield strength. All other properties (3H) (i.e. reduction of area, elongation, and Charpy impact) exceeded minimum mechanical property specifications. Once the optimum heat treatment for the Ti-6Al-6V-2Sn body section rear was established, MTL proceeded to heat treat four lots of six components each and one quartered body section (for test samples) for a total of 24 bodies and four test pieces. Each heat treat lot was tested for mechanical properties by obtaining two tensile and two V-notch Charpy impact specimens from the quartered body section the results are shown in Table 4.

Table 4. MECHANICAL PROPERTY RESULTS FOR BODY SECTION REAR Ti-6Al-6V-2Sn SOLUTION TREATED 1600°F, 2 HOURS, WATER QUENCHED, AGED 975°F, FOR 4 -1/2 HOURS, AIR COOLED

Specification Identification	0.1 % Y.S. (ksi)	0.2 % Y.S. (ksi)	U.T.S. (ksi)	Elon. (%)	R.A. (%)	Charpy Impact -40°F (ft-lb)	Hardness (HRC)
AI	174	177	192	9.6	32.6	7.7	41.3
AO	173	176	192	9.7	27.8	7.5	41.5
BI	173	176	192	10.7	31.8	7.4	41.1
BO	175	179	194	8.3	26.1	8.3	41.1
CI	173	175	190	7.1	27.4	7.0	41.2
CO	172	176	192	10.3	29.5	7.7	41.0
DI	171	175	190	9.3	27.3	7.5	40.9
DO	172	176	192	7.8	20.5	7.0	41.4

Tensile properties for these four lots were higher than anticipated. The original minimum yield strength requirement of 170 ksi was exceeded in all cases, and the percent reduction of area substantially exceeded those properties for the heat treatment established in this investigation.

The authors can only speculate as to the reason for the slightly higher tensile properties for the four prototype lots. Possible reasons include: (1) longer furnace soakings times for solution treating and aging due to the larger lot sizes, and (2) better furnace temperature control.

MICROSTRUCTURE

Photomicrographs were obtained from a side wall location for both the as-forged and various heat-treated conditions. The rear bodies were forged in the α plus β region at 1650°F, which is approximately 75°F below the β transus. As indicated earlier, the heat treatment study consisted of solution treating at 1600°F and aging at temperatures from 950°F to 1075°F.

Figure 1a is a photomicrograph of the as-forged condition. The microstructure consists of both equiaxed and elongated primary α in a β matrix which is typical for Ti-6Al-6V-2Sn when forged high in the α plus β region.

Figure 1b is a photomicrograph for the selected aging temperature of 975°F. As would be expected, the microstructure consists of equiaxed and elongated primary α which was established during forging, α-prime (martinsitic α) the transformation product of β during water quenching plus a retained β matrix. Again, it is a typical microstructure for this alloy when forged and heat treated in the α plus β region.

CONCLUSIONS

The purpose of this study was to establish a heat treatment for Ti-6Al-6V-2Sn which results in meeting the mechanical property specifications as required for the 155-mm T5119 torsional impact test projectile rear body. The minimum mechanical properties specified for this application are room temperature values of 170 ksi yield strength, 6% elongation, 13% reduction of area, and a V-notch Charpy energy of 6 ft-lb at -40°F.

The Ti-6Al-6V-2Sn heat treatment investigation established that the mechanical property requirements could be obtained by solution treating at 1600°F for two hours and water quenching followed by aging at 975°F for 4-1/2 hours and air cooling to room temperature.

The mechanical property data base established as a function of heat treatment in this study will be valuable for the T5119, as well as future projectile programs, when a die which results in a forged wall thickness of approximately 1-5/8" is used. It should be clearly understood, however, that the heat treatment selected for this program may not result in the required properties for this component when using its customary size forging die that produces thinner forging wall thicknesses of 1" or less.

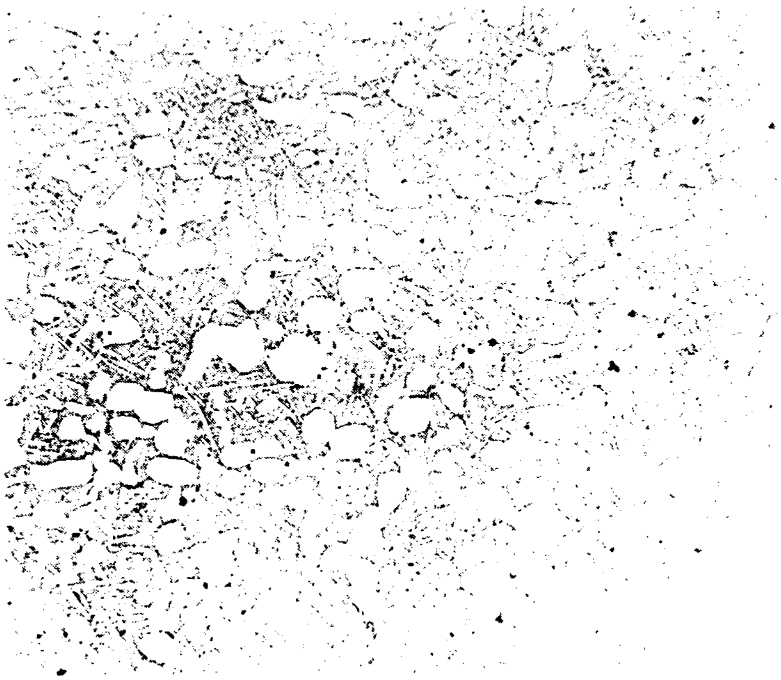

Figure 1a. Ti-6Al-6V-2Sn as-forged, Mag. 500X.

Figure 1b. Ti-6Al-6V-2Sn solutionized 1600^{o}F for 2 hours, water quenched, aged at 975^{o}F for 4-1/2 hours, air cooled, Mag. 500X.

DISTRIBUTION LIST

No. of Copies	To
1	Office of the Under Secretary of Defense for Research and Engineering, The Pentagon, Washington, DC 20301
	Commander, U.S. Army Laboratory Command, 2800 Powder Mill Road, Adelphi, MD 20783-1145
1	ATTN: AMSLC-IM-TL
1	AMSLC-CT
	Commander, Defense Technical Information Center, Cameron Station, Building 5, 5010 Duke Street, Alexandria, VA 22304-6145
2	ATTN: DTIC-FDAC
	Metals and Ceramics Information Center, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201
1	ATTN: Harold Mindlin
	Commander, Army Research Office, P.O. Box 12211, Research Triangle Park, NC 27709-2211
1	ATTN: Information Processing Office
	Commander, U.S. Army Materiel Command (AMC), 5001 Eisenhower Avenue, Alexandria, VA 22333
1	ATTN: AMCLD
	Commander, U.S. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD 21005
1	ATTN: AMXSY-MP, Director
	Commander, U.S. Army Missile Command, Redstone Scientific Information Center, Redstone Arsenal, AL 35898-5241
1	ATTN: AMSMI-RD-CS-R/Doc
1	AMSMI-CS, R. B. Clem
	Commander, U.S. Army Armament Research, Development and Engineering Center, Picatinny Arsenal, Dover, NJ 07806-5000
1	ATTN: AMCPM-NUC, COL B. Levine, Bldg. 1715
1	AMCPM-NUC, Mr. K. Widmaier, Bldg. 1715
1	SMCAR-FS, Mr. C. Spinelli, Bldg. 94
1	SMCAR-FSN-N, Mr. G. Sacco, Bldg. 354
1	SMCAR-FSN-N, Mr. J. Carty, Bldg. 354
1	SMCAR-FSN-N, Mr. A. Scigliano, Bldg. 354
1	AMCPM-NUC-A, Mr. C. Krupacs, Bldg. 1715
1	SMCAR-FSN-N, Mr. R. Wilgus, Bldg. 354
2	Technical Library
	Commander, U.S. Army Tank-Automotive Command, Warren, MI 48397-5000
1	ATTN: AMSTA-ZSK
2	AMSTA-TSL, Technical Library
1	AMSTA-RCK
	Commander, U.S. Army Foreign Science and Technology Center, 220 7th Street, N.E., Charlottesville, VA 22901
3	ATTN: AIFRTC, Applied Technologies, Gerald Schlesinger
	Commander, U.S. Army Aviation Systems Command, Aviation Research and Technology Activity, Aviation Applied Technology Directorate, Fort Eustis, VA 23604-5577
1	ATTN: SAVDL-E-MOS (AVSCOM)
1	SAVDL-EU-TAP
	U.S. Army Aviation Training Library, Fort Rucker, AL 36360
1	ATTN: Building 5906--5907

No. of Copies	To
	Commander, U.S. Army Aviation Systems Command, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798
1	ATTN: AMSAV-GTD
1	AMSAV-E
1	AMCPEO-AV
	Naval Research Laboratory, Washington, DC 20375
1	ATTN: Code 5830
1	Code 2627
	Chief of Naval Research, Arlington, VA 22217
1	ATTN: Code 471
1	Edward J. Morrissey, WRDC/MLTE, Wright Patterson Air Force Base, OH 45433
	Commander, U.S. Air Force Wright Research & Development Center, Wright-Patterson Air Force Base, OH 45433-6523
1	ATTN: WRDC/MLC
1	WRDC/MLLP, D. M. Forney, Jr.
1	WRDC/MLBC, Mr. Stanley Schulman
1	WRDC/MLXE, A. Olevitch
	NASA - Marshall Space Flight Center, MSFC, AL 35812
1	ATTN: Mr. Paul Schuerer/EH01
	Chief of Naval Research, Washington, DC 20350
1	ATTN: OP-987, Director
	Aeronautical Systems Division (AFSC), Wright-Patterson Air Force Base, OH 45433-6503
1	ATTN: ASD/ENFEF, D. C. Wight
1	ASD/ENFTV, D. J. Wallick
1	ASD/XRM, G. B. Bennett
	Air Force Armament Laboratory, Eglin Air Force Base, FL 32542
1	ATTN: AFATL/DLYA, V. D. Thornton
	Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, OH 45433
1	ATTN: AFFDL/FIES, J. Sparks
	NASA - Ames Research Center, Army Air Mobility Research and Development Laboratory, Mail Stop 207-5, Moffett Field, CA 94035
1	ATTN: SAVDL-AS-X, F. H. Immen
	NASA - Johnson Spacecraft Center, Houston, TX 77058
1	ATTN: JM6
1	ES-5
	Naval Air System Command, Department of the Navy, Washington, DC 20360
1	ATTN: AIR-03PAF
1	AIR-5203
1	AIR-5164J
1	AIR-530313
	Naval Post Graduate School, Monterey, CA 93948
1	ATTN: Code 57BP, R. E. Ball
	Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren, VA 22448
1	ATTN: Code G-54, Mr. J. Hall
1	Code G-54, Dr. B. Smith
	Commander, Rock Island Arsenal, Rock Island, IL 61299-6000
1	ATTN: SMCRI-SEM-T

No. of Copies	To
	Armament Systems, Inc., 326 W. Katella Ave., 4-K, Orange, CA 92667
1	ATTN: J. Musch
	Bell Helicopter Company, A Textron Company, P.O. Box 482, Fort Worth, TX 76101
1	ATTN: J. R. Johnson
	Boeing Helicopters, P.O. Box 16858, Philadelphia, PA 19142-0858
1	ATTN: N. Caravasos M/S P30-27
1	Cessna Military, P.O. Box 7704, Wichita, KS 67277-7704
	FMC Corporation, Central Engineering Labs, 1185 Coleman Avenue, Box 80, Santa Clara, CA 95052
1	ATTN: Gary L. Boerman
	Gruman Aerospace Corporation, South Oyster Bay Road, Bethpage, NY 11714
1	ATTN: Technical Information Center, J. Davis
	IIT Research Institute, 10 West 35th Street, Chicago, IL 60616
1	ATTN: K. McKee
	Kaman Aerospace Corporation, Old Winsor Road, Bloomfield, CT 06002
1	ATTN: H. E. Showalter
	Lockheed-California Company, A Division of Lockheed Aircraft Corporation, Burbank, CA 91503
1	ATTN: Technological Information Center, 84-40, U-35, A-1
	LTV Aerospace and Defense Company, Box 65003, Dallas, TX 95265
1	ATTN: Dr. D. Peterson, M/S TH-85
1	Mr. R. Miller, M/S TH-85
	Martin Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, FL 32805
1	ATTN: Library, M. C. Griffith
	McDonnell Douglas Helicopter Company, 5000 E. McDowell Road, Mesa, AZ 85205
1	ATTN: Mr. L. Soffa
1	Mr. A. Hirko
	McDonnell Douglas Corporation, 3855 Lakewood Boulevard, Long Beach, CA 90846
1	ATTN: Technical Library, Cl 290/36-84
	Northrop Corporation, Aircraft Division, 3901 W. Broadway, Hawthorne, CA 90250
1	ATTN: Mgr. Library Services, H. W. Jones
	Parker Hannifin, 14300 Alton Pkwy., Irvine, CA 92718-1814
1	ATTN: C. Beneker
	Sikorsky Aircraft, A Division of United Aircraft Corporation, Main Street, Stratford, CT 06601
1	ATTN: Mel Schwartz, Chief of Metals
	TIMET, Box 2128, Henderson, NV [illegible]9889
1	ATTN: Mr. E. E. Mild
	RMI Titanium Company, 1000 Warren Avenue, Niles, OH 44446
1	ATTN: Mr. J. Schley
	Georgia Institute of Technology, School of Mechanical Engineering, Atlanta, GA 30332
1	ATTN: Mechanical Engineering Library

No. of Copies	To
	L. Raymond Associates, P.O. Box 7925, Newport Beach CA 92658-7925
1	ATTN: Dr. L. Raymond
	Brown University, Division of Engineering, Providence, RI 02912
1	ATTN: Prof. J. Duffy
	SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025
1	ATTN: Dr. D. Shockey
	Illinois Institute of Technology, Metallurgical and Materials Engineering Department, Chicago, IL 60616
1	ATTN: Dr. Norman Breyer
	Director, U.S. Army Materials Technology Laboratory, Watertown, MA 02172-0001
2	ATTN: SLCMT-TML
2	Authors

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING -
Ernest N. Kinas and Charles F. Hickey, Jr.

Technical Report MTL TR 90-47, September 1990, 7 pp-illus-tables,

AD ________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Key Words

Titanium alloys
Forgings
Artillery shells

This paper addresses a mechanical property investigation on Ti-6Al-6V-2Sn which is used for the rear body component of the T5119 artillery torsional impact test projectile. Quantities of this projectile were produced during 1988 and 1989 at the U.S. Army Materials Technology Laboratory (MTL) upon request from PM-NUC. These projectiles had been produced at MTL approximately 10 years ago. In the earlier work, a die which resulted in a forged wall thickness less than 1 inch, which is customary for this component, was used. In the recent program, a substitute die which resulted in a heavier forged wall thickness of approximately 1-5/8 inch had to be used. This was necessary due to the fracture failure of the customary die. Because of the time constraints placed upon MTL by PM-NUC to produce and deliver both the T5119 and T5106 test projectiles, time was not available to make a replacement die; therefore, it was necessary to conduct a heat treatment study of the thicker wall forgings in order to meet the mechanical property requirements for the rear body component. One solution temperature and five aging temperatures were used in this investigation. Tensile and Charpy impact properties were obtained in addition to other factors such as sampling procedures and microstructure. As a result of these findings, an optimum heat treatment for the investigated conditions was established that met the design mechanical properties for this artillery shell component.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING -
Ernest N. Kinas and Charles F. Hickey, Jr.

Technical Report MTL TR 90-47, September 1990, 7 pp-illus-tables,

AD ________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Key Words

Titanium alloys
Forgings
Artillery shells

This paper addresses a mechanical property investigation on Ti-6Al-6V-2Sn which is used for the rear body component of the T5119 artillery torsional impact test projectile. Quantities of this projectile were produced during 1988 and 1989 at the U.S. Army Materials Technology Laboratory (MTL) upon request from PM-NUC. These projectiles had been produced at MTL approximately 10 years ago. In the earlier work, a die which resulted in a forged wall thickness less than 1 inch, which is customary for this component, was used. In the recent program, a substitute die which resulted in a heavier forged wall thickness of approximately 1-5/8 inch had to be used. This was necessary due to the fracture failure of the customary die. Because of the time constraints placed upon MTL by PM-NUC to produce and deliver both the T5119 and T5106 test projectiles, time was not available to make a replacement die; therefore, it was necessary to conduct a heat treatment study of the thicker wall forgings in order to meet the mechanical property requirements for the rear body component. One solution temperature and five aging temperatures were used in this investigation. Tensile and Charpy impact properties were obtained in addition to other factors such as sampling procedures and microstructure. As a result of these findings, an optimum heat treatment for the investigated conditions was established that met the design mechanical properties for this artillery shell component.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING -
Ernest N. Kinas and Charles F. Hickey, Jr.

Technical Report MTL TR 90-47, September 1990, 7 pp-illus-tables,

AD ________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Key Words

Titanium alloys
Forgings
Artillery shells

This paper addresses a mechanical property investigation on Ti-6Al-6V-2Sn which is used for the rear body component of the T5119 artillery torsional impact test projectile. Quantities of this projectile were produced during 1988 and 1989 at the U.S. Army Materials Technology Laboratory (MTL) upon request from PM-NUC. These projectiles had been produced at MTL approximately 10 years ago. In the earlier work, a die which resulted in a forged wall thickness less than 1 inch, which is customary for this component, was used. In the recent program, a substitute die which resulted in a heavier forged wall thickness of approximately 1-5/8 inch had to be used. This was necessary due to the fracture failure of the customary die. Because of the time constraints placed upon MTL by PM-NUC to produce and deliver both the T5119 and T5106 test projectiles, time was not available to make a replacement die; therefore, it was necessary to conduct a heat treatment study of the thicker wall forgings in order to meet the mechanical property requirements for the rear body component. One solution temperature and five aging temperatures were used in this investigation. Tensile and Charpy impact properties were obtained in addition to other factors such as sampling procedures and microstructure. As a result of these findings, an optimum heat treatment for the investigated conditions was established that met the design mechanical properties for this artillery shell component.

U.S. Army Materials Technology Laboratory
Watertown, Massachusetts 02172-0001
MECHANICAL PROPERTY CHARACTERIZATION OF THICK WALL Ti-6Al-6V-2Sn FORGING -
Ernest N. Kinas and Charles F. Hickey, Jr.

Technical Report MTL TR 90-47, September 1990, 7 pp-illus-tables,

AD ________
UNCLASSIFIED
UNLIMITED DISTRIBUTION

Key Words

Titanium alloys
Forgings
Artillery shells

This paper addresses a mechanical property investigation on Ti-6Al-6V-2Sn which is used for the rear body component of the T5119 artillery torsional impact test projectile. Quantities of this projectile were produced during 1988 and 1989 at the U.S. Army Materials Technology Laboratory (MTL) upon request from PM-NUC. These projectiles had been produced at MTL approximately 10 years ago. In the earlier work, a die which resulted in a forged wall thickness less than 1 inch, which is customary for this component, was used. In the recent program, a substitute die which resulted in a heavier forged wall thickness of approximately 1-5/8 inch had to be used. This was necessary due to the fracture failure of the customary die. Because of the time constraints placed upon MTL by PM-NUC to produce and deliver both the T5119 and T5106 test projectiles, time was not available to make a replacement die; therefore, it was necessary to conduct a heat treatment study of the thicker wall forgings in order to meet the mechanical property requirements for the rear body component. One solution temperature and five aging temperatures were used in this investigation. Tensile and Charpy impact properties were obtained in addition to other factors such as sampling procedures and microstructure. As a result of these findings, an optimum heat treatment for the investigated conditions was established that met the design mechanical properties for this artillery shell component.

DEPARTMENT OF THE ARMY
U.S. ARMY LABORATORY COMMAND
MATERIALS TECHNOLOGY LABORATORY
ATTN: SLCMT-IMA-V
Watertown, Massachusetts 02172-0001

Official Business